The last glyph in the inscription is a Katun sign with the numeral 14 above it, and a sign for "beginning" in front of it, and indicates that the last date is the beginning of a 14th Katun. If we turn to the table for the 9th Cycle of the 54th Great Cycle, from which we started, it will be seen that the 14th Katun of that cycle does commence with the date 6 *Ahau* 13 *Muan*.

It is simply impossible that the identity of the dates expressed in the inscription with those to which the computations have guided us can throughout be fortuitous. Very nearly half of the forty-eight glyphs in the inscription have been accounted for, and I have no doubt that when the inscription passes under Mr Goodman's scrutiny he will be able to give us much information about the remaining glyphs which I have passed over as undeciphered.

It can, I think, therefore, be fairly claimed for Mr. Goodman that his researches have raised the veil of mystery which has for so long hung over the carved hieroglyphic writing of the Mayas.

"Influence of Acids and Alkalis upon the Electrotonic Currents of Medullated Nerve." By AUGUSTUS D. WALLER, M.D., F.R.S. Received June 10,—Read June 17, 1897.

A. *The Effect of Acids and of Alkalis.*

Considering that electrotonic currents are characteristic of living medullated nerve, that such currents are due to electrolytic polarisation, and that such electrolysis must primarily consist in a liberation of electronegative principles (oxygen, acid, &c.) at the anode, and of electropositive principles (hydrogen, base, &c.) at the kathode, the first and most obvious test to be made is to examine comparatively the action of acids and bases upon anelectrotonic and katelectrotonic currents.

On the supposition that a medullated nerve-fibre is composed of two different electrolytes, white fatty sheath and grey proteid axis, and that electrolytic polarisation is aroused at the interface of separation between these two electrolytes, we may expect to find, as the characteristic acidic effect, diminution of A and increase of K, and as the characteristic basic effect, increase of A and diminution of K.

This expectation is in the main substantiated by experiment, although owing to the somewhat narrow range of concentration within which moderate effects are produced, it is not common to obtain effects in both of the two opposite directions in a single experiment. The reagent may be too weak, in which case neither A nor K are altered, or it may be too strong, in which case both A

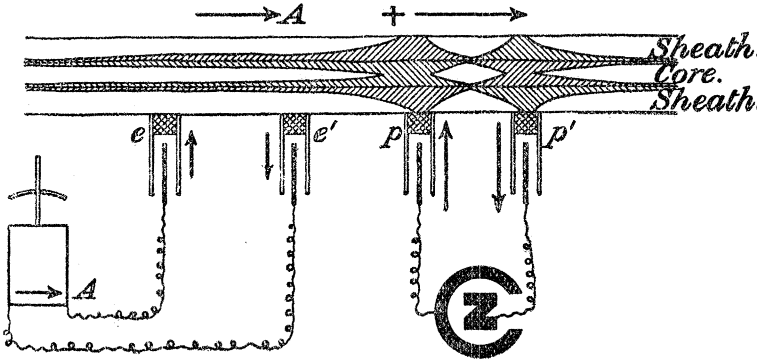

FIG. 1.

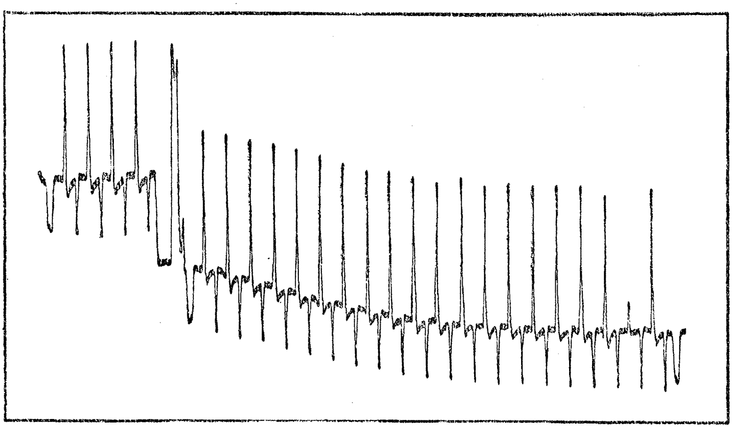

FIG. 2.—Potassium hydrate, N/50 (2358).

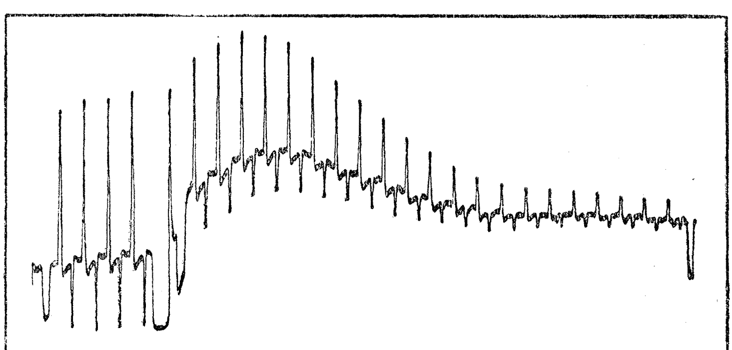

FIG. 3.—Effect of sulphuric acid, N/5 upon A and K (2359).

and K are rapidly and equally abolished. Plates 2358 and 2359 illustrate this point, the former exhibiting the defective action of

a base below optimum strength, the latter exhibiting the excessive action of an acid above optimum strength.

Partly for this reason, and partly in order to eliminate the resistance factor, results are formulated in terms of the relative magnitude of the quotient A/K as well as in terms of the absolute magnitudes of A and K. This point is illustrated by plate 2410.

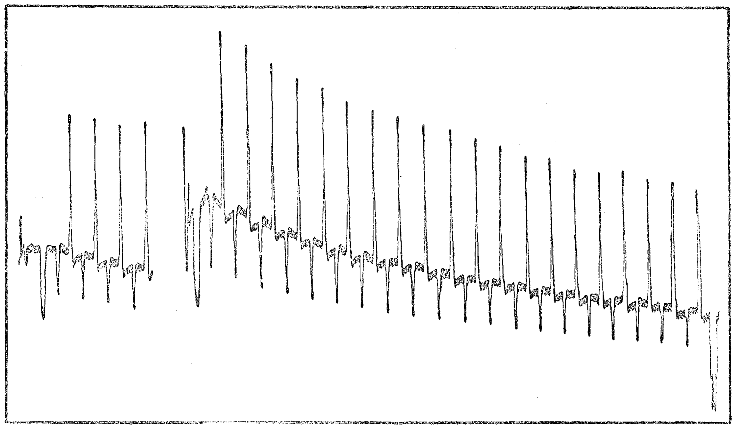

Fig. 4.—Oxalic acid N/20 (2410).

Method.—The disposition of the object of experiment is in accordance with the diagram, and the galvanometer (dead-beat) is arranged

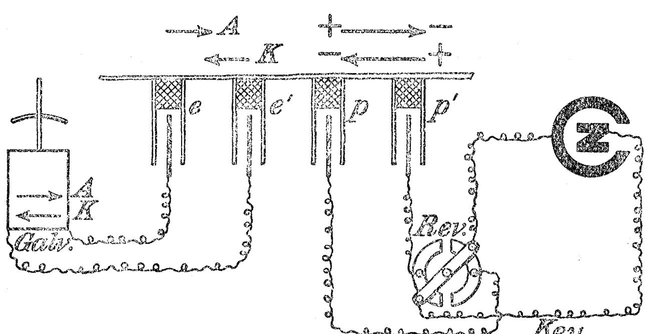

Fig. 5.—Diagram of apparatus. The excised nerve rests upon two pairs of unpolarisable electrodes, *pp'* leading in the polarising current, *ee'* leading out the extrapolar or electrotonic current.

to give a continuous record (lasting usually from 30 to 60 minutes) as described in a previous communication (Croonian Lecture, 1896, 'Phil. Trans.,' B, 1897).

In the earlier observations series of anelectrotonic and of katelectrotonic currents were separately recorded. In the later observations the A and K currents were taken at alternate minutes by means of a rotating reverser in the polarising circuit. In the finished records A currents read upwards, and K currents read downwards.

Results.—The characteristic results of acid and base upon the anodic and kathodic currents respectively are summarised in the following four observations (Plates 2360, 2412, 2429, 2432).

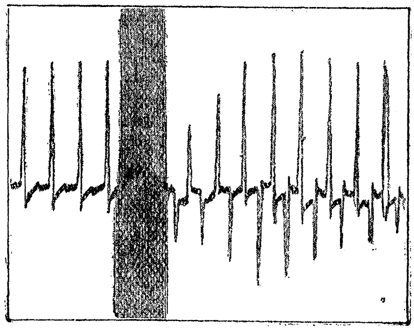

FIG. 6.—Action of CO_2 on A and K (2429).

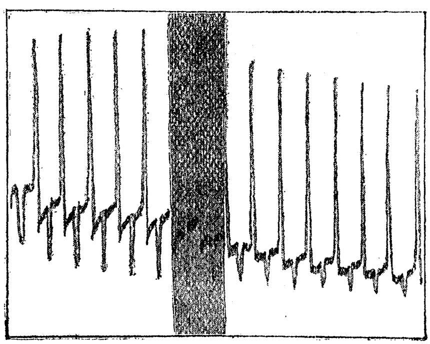

FIG. 7.—Action of ammonia vapour on A and K (2432).

They illustrate the rule that:

Acidification diminishes the quotient A/K.
Basification increases the quotient A/K.

A diminution of the quotient A/K may be by diminution of A or by increase of K. In plate 2412 it is mainly by diminution of A. In this case the augmentation of K is comparatively small. The record in fact approaches towards the type of plate 2359. In other

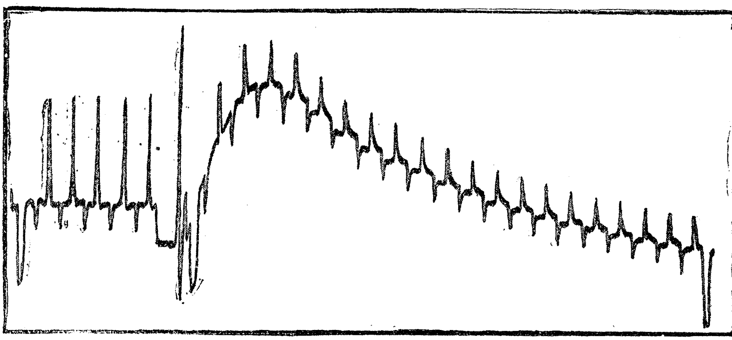

FIG. 8.—Effect of propionic acid, N/10, upon A and K (2412).

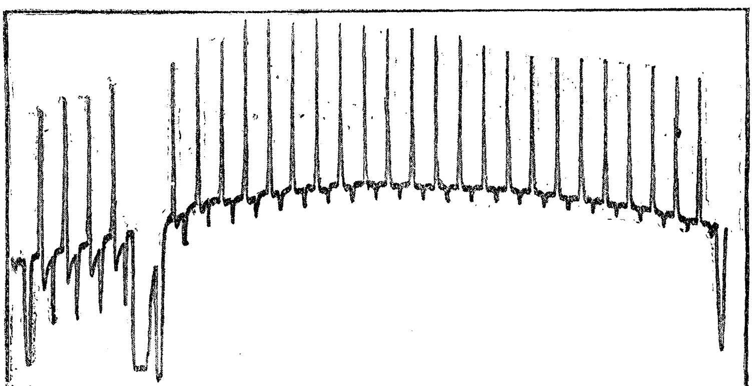

FIG. 9.—Effect of a weak alkaline bath (KOH N/20 or 0·285 per 100) upon A and K (2360).

experiments (*e.g.*, in plates 2429 and 2424) the diminution of A/K is principally due to increase of K.

An increase of the quotient A/K may be by increase of A or by diminution of K. In plate 2360, and in most of my other experiments, it is mainly by diminution of K.

The two plates illustrate the points that acid affects A more than it does K, and that base affects K more than it does A.

As mentioned above, acid above optimum strength causes a diminution of K; we may, therefore, say that weak acid causes augmented K, and stronger acid diminished K.

On testing carefully with very weak acids we shall find that at a strength below the optimum (giving diminished A and increased K, *e.g.*, Plate 2429) the "very weak" acid causes augmented A. We may, therefore, say that very weak acid causes augmented A and rather stronger acid diminished A. And in general summary of the action of acid from minimal to maximal effective we may state that:—

(1) The weakest acid gives increased A.
(2) Slightly stronger acid gives diminished A and increased K.
(3) Still stronger acid gives diminished K.

These statements are the outcome of a considerable number of observations, and one may hardly hope to verify the progressive action of acid from minimal to maximal in a single observation with a single acid. Nor is it easy to give numbers in lieu of the indefinite qualifications "weak" and "strong." This much may, however, be said to give an idea of the order of magnitudes dealt with. The second degree of change may be expected in consequence of bathing the nerve for one minute in an acid solution of a strength between N/20 and N/10. The free passage of "much" CO_2 into the nerve-chamber usually affects the second degree of change in its most typical form. A small amount of CO_2, *e.g.*, a few puffs of expired air, will more probably affect the first degree of change. A bath of one minute's duration in a N/5 solution of mineral acid will almost certainly affect the third degree of change. A diminution of K by CO_2 is rare (*e.g.*, 2363).

B. *The Effect of Carbonic Acid and of Tetanisation.*

I have given particular attention to the action of carbon dioxide and of tetanisation upon the A and K currents, in prosecution of observations already reported concerning the action-currents of nerve* and the influence of temperature upon the A and K currents.

The usual and typical effects of carbonic acid are of the characteristic acidic type, consisting in a diminution of A and an augmentation of K.

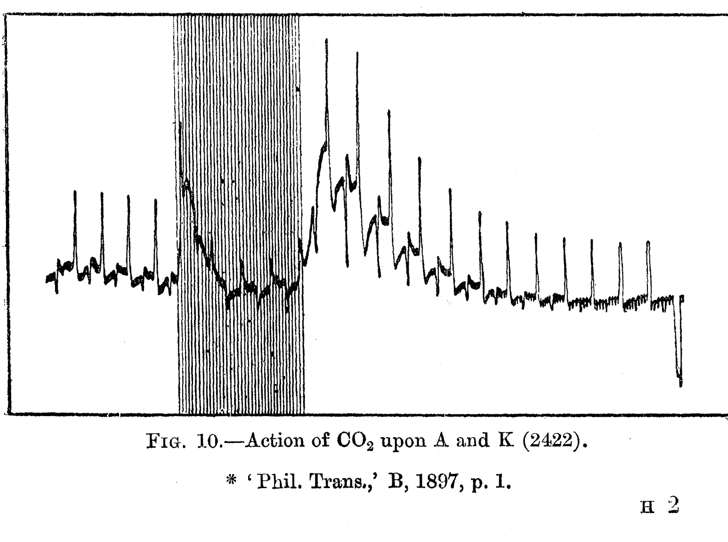

FIG. 10.—Action of CO_2 upon A and K (2422).

* 'Phil. Trans.,' B, 1897, p. 1.

Less commonly, and by a slighter degree of action of CO_2, the A current may be increased, while as the most pronounced degree of action of CO_2 the K current may be diminished.

In order of gravity the effects are:

1. Augmentation of A.
2. $\left\{\begin{array}{l}\text{Diminution of A.}\\ \text{Augmentation of K.}\end{array}\right.$
3. Diminution of K.

The second being the usual and typical result, the first and third being less frequently observed.

Prolonged tetanisation (five minutes) modifies the A and K currents in a similar direction, causing a diminution (but sometimes an augmentation) of the A current and an augmentation (nearly always) of the K current (2424).

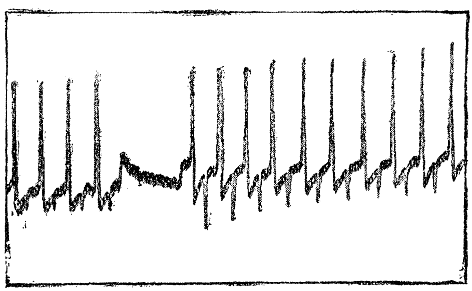

Fig. 11.—Effect of tetanisation on A and K (2424).

Thus it will be seen that the two groups of results, although not absolutely coincident, are in reasonable agreement, the two points of difference being that an augmentation of the A current has been more frequent by tetanisation than by CO_2; while a diminution of the K current, rarely observed in consequence of the full action of CO_2, has been still more rare (once only, and that not very markedly, 2287) in consequence of tetanisation.

Of these several effects the most characteristic has been the augmentation of K (2424, fig. 11) with a consequent diminution of the quotient A/K. And although—in correspondence with the not infrequent augmentation of A, there has been not infrequently an augmentation of A/K—this latter augmentation has generally been slight or even doubtful as compared with its opposite. I have been led to admit diminution of A/K as typical (2424, fig. 11, 2425 2427), and a distinct augmentation of A/K as exceptional (2387, 2388, 2393) or doubtful. (A similar augmentation of A/K by predominant augmentation of A has not hitherto come under my observation in consequence of the action of CO_2.)

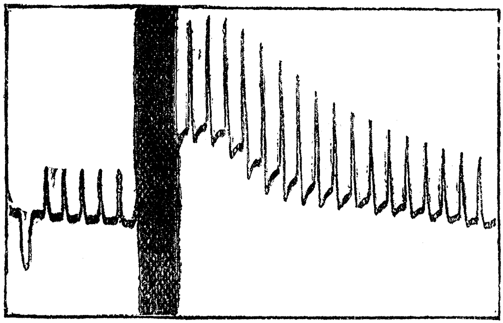

FIG. 12.—Effect of CO_2 on A (primary augmentation) (2199).

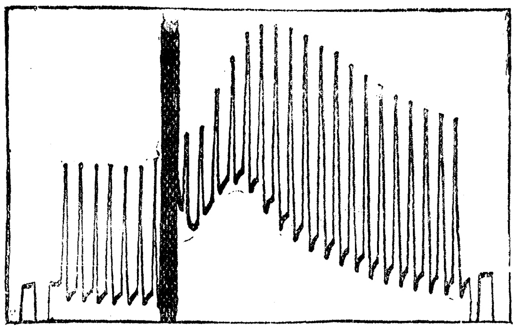

FIG. 13.—Effect of CO_2 on A (primary diminution, secondary augmentation) (2200).

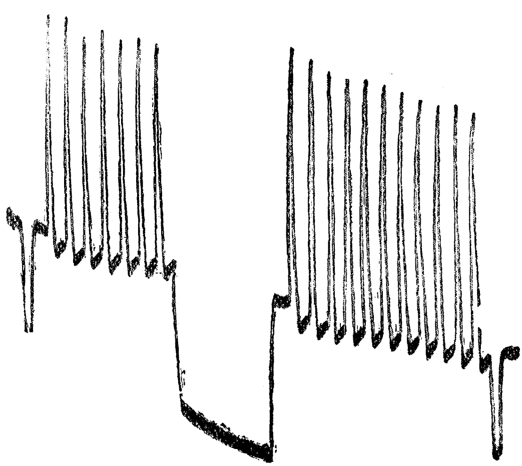

FIG. 14.—Effect of tetanisation on A (augmentation) (2295).

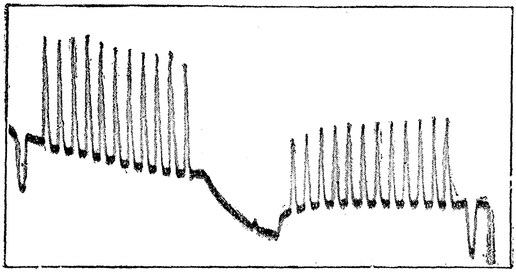

Fig. 15.—Effect of tetanisation on A (diminution) (2296).

The chief results of these experiments (and of those on temperature*) are to the following effect :—

The katelectrotonic current is augmented in consequence of (*a*) rise of temperature, (*b*) acidification, (*c*) tetanisation.

It is diminished by basification. Its augmentation by tetanisation gradually declines during repose.

The anelectrotonic current is diminished in consequence of rise of temperature. It is augmented by "very slight" acidification and by tetanisation, diminished by "slight" acidification and tetanisation.

The characteristic effect of the presumably "dissociative" influence of rise of temperature, of acidification, and of tetanisation, is a diminution of the quotient A/K. A slighter and less assured effect of tetanisation consists in an augmentation of the quotient A/K.

Note.—The foregoing observations form part of an investigation of the action of reagents on nerve, towards the expenses of which a grant was made by the Physiological Sub-committee of the British Association to Miss S. C. M. Sowton, acting as my assistant in the prosecution of the research. Our experiments during the last year have fallen under four heads :—(1) On the action of acids and alkalis upon action-currents; (2) on the action of acids and alkalis upon electrotonic currents; (3) on the action of temperature upon electrotonic currents; (4) on the action of anæsthetics, of neutral salts, and of alkaloids upon electrotonic currents. The first and fourth of these four groups are not sufficiently advanced for publication, and have required to be prefaced by the second group which is now reported upon. The third group is briefly reported on in 'Roy. Soc. Proc.,' Dec. 17, 1896.

I wish to acknowledge Miss Sowton's active participation during the past year in the work above specified. Experiments under headings (1) and (4) will, it is to be hoped, be sufficiently advanced for publication during the coming year.

* 'Roy. Soc. Proc.,' vol. 60, p. 383.

Table I.—Influence of Acids and Alkalis on the A and K Currents provoked by one Leclanché Cell. (Inter- and Intra-polar Distances each of 1 cm.)

Plate No.	Time.	A.	K.	A/K.	Remarks.
2158	Normal	+19·5	− 3·0	6·5	Diminution of the A/K quotient by CO_2.
			CO_2		
	2—3 mins.	+ 8·0	− 3·5	2·3	
	12—13 ,,	+24·0	− 5·0	4·8	
2195	Normal	..	−12·5	..	Primary augmentation of K by CO_2.
			CO_2		
	2 mins.	..	−17·5		
	5 ,,	..	−23·0		
	10 ,,	..	−23·0		
	15 ,,	..	−18·0		
	20 ,,	..	−15·0		
2199 (fig. 12)	Normal	+ 7·0	..	..	Primary augmentation of A by CO_2.
			CO_2		
	3 mins.	+14·0			
	5 ,,	+15·0			
	10 ,,	+12·5			
	15 ,,	+ 9·5			
	20 ,,	+ 8·5			
	25 ,,	+ 7·5			

Table I—*continued.*

Plate No.	Time.	A.	K.	A/K.	Remarks.
2200 (fig. 13)	Normal	+21·0	..	..	Primary diminution of A by CO_2.
		CO_2 for 1 min.			
	2 mins.	+ 9·5			
	5 "	+15·0			
	10 "	+23·0			
2235	Normal	+ 7·5	− 1·5	5·0	
		CO_2 for 1 min.			
	2—3 mins.	+ 2·5	− 1·5	1·7	Diminution of A/K.
	12—13 "	+14·5	− 4·0	3·6	
2236	Normal	+ 9·5	− 4·5	2·1	
		CO_2 for 1 min.			
	10—11 mins.	+12·0	− 7·5	1·6	
2351	Normal	+19·0	− 2·5	7·6	Ill-marked effect.
		H_2SO_4, N/20			
		+18·0	− 3·0	6·0	

2352	Normal	+13·0	− 6·5	2·0	Marked augmentation of both A and K. A/K slightly diminished.
		Acetic acid, N/10			
		+21·0	−12·0	1·75	
2354	Normal	+30·0	−12·5	2·4	Augmentation of the A/K quotient by soda. Absolute diminution of A and of K.
		NaOH, N/30			
	3—4 mins.	+14·5	− 6·5	2·25	
	13—14 ,,	+22·0	− 4·0	5·5	
	23—24 ,,	+23·0	− 3·0	7·7	
	33—33 ,,	+22·5	− 3·0	7·5	
2355	Normal	+22·5	− 7·0	3·2	Augmentation of the A/K quotient by soda. Both A and K are absolutely diminished, but the diminution of K is relatively greater than of A. Diminution of A/K by sulphuric acid.
		NaOH, N/20			
	2—3 mins.	+14·5	− 2·0	7·2	
		H_2SO_4. N/10			
		+11·0	− 5·0	2·2	
2356	Normal	+12·0	− 2·0	6·0	Ill-marked effect.
		H_2SO_4, N/20			
	After	+10·0	− 1·5	6·7	

Table I—*continued.*

Plate No.	Time.	A.	K.	A/K.	Remarks.
2357	Normal	+16·0	− 3·5	4·5	Diminution of A. Increase of K. Slight but distinct. Diminution of A/K.
		HCl, N/20			
	5—6 mins.	+14·5	− 4·0	3·8	
2358 (fig. 2)	Normal	+17·5	− 7·0	..	Absence of alteration of A and K by potash of less than optimum strength. The A/K quotient is practically constant. Alkali too weak.
		KOH, N/50			
	4—5 mins. 34—35 ,,	+18·5 +18·5	− 7·5 − 7·0		
2359 (fig. 3)	Normal	+21·5	− 9·0	2·4	The parallel diminution of A and of K by sulphuric acid of greater than optimum strength. The A/K quotient is not markedly altered. Acid too strong.
		H_2SO_4, N/5			
	3—4 mins. 13—14 ,, 23—24 ,, 33—34 ,,	+16·5 +13·0 + 6·0 + 3·5	− 5·5 − 4·0 − 2·0 − 1·5	3·0 3·25 3·0 2·3	

2360 (fig. 9)	Normal	+19·0	− 8·0	2·4	Augmentation of the quotient A/K by potash in optimum concentration. K is absolutely diminished.
		KOH, N/20			
	3—4 mins.	+18·0	− 2·3	7·8	
	33—34 „	+15·0	− 1·5	10·0	
2363	Normal	+17·0	−12·0	1·4	Exceptional primary diminution of K by CO_2.
		CO_2			
	2—3 mins.	+ 2·5	− 3·5	0·7	
	12—13 „	+19·0	−15·5	1·2	
2396	Normal	+15·0	− 3·5	4·3	Ill-marked effect. Acid too strong.
		H_2SO_4, N/10			
	After	+12·0	− 2·0	6·0	
2397	Normal	+21·0	− 6·5	3·25	Gradual and not well-marked effect. Acid too weak.
		Formic acid, N/40			
	30—31 mins.	+15·0	− 5·0	3·0	

Table I—*continued*.

Plate No	Time.	A.	K.	A/K.	Remarks.
2400	Normal	+18·0	−5·5	3·3	Acid too strong?
		H_2SO_4, N/15			
	After	+10·0	−3·5	2·8	
2401	Normal	+15·0	−5·5	2·7	Acid too strong?
		H_2SO_4, N/15			
	5—6 mins.	+16·0	−5·5	2·9	
	25—26 „	+12·0	−5·0	2·4	
2402	Normal	+15·5	−5·0	3·1	Diminution of A/K.
		H_2SO_4, N/20			
	10—11 mins.	+12·5	−6·5	1·9	
2406	Normal	+22·0	−4·5	4·9	No well-marked effect.
		H_2SO_4, N/15			
	4—5 mins.	+23·0	−4·0	5·75	

2407	Normal	+12·5	− 2·5	5·0	Diminution of A/K.
		H_2SO_4, N/20			
	1—2 mins.	+16·0	− 4·5	3·5	
2408	Normal	+13·5	− 3·0	4·5	No well-marked effect.
		Formic acid, N/50			
	5—6 mins.	+16·0	− 4·0	4·0	
2410 (fig. 4)	Normal	+19·0	− 5·0	3·8	It is necessary to correct for altered resistance before concluding that there is any absolute alteration of A or K. In this instance the resistance was reduced by 25 per cent. by the acid, and the measurements must be corrected accordingly to +17, −7, +14, −4·5.
		Oxalic acid, N/20			
	3—4 mins.	+23·0	− 9·0	2·5	
	33—34 „	+19·0	− 6·0	3·2	
2411	Normal	+20·0	− 5·5	3·6	Slight effect, but distinct.
		Propionic acid, N/40			
	4—5 mins.	+20·0	− 6·5	3·0	

Table I—*continued.*

Plate No.	Time.	A.	K.	A/K.	Remarks.
2412 (fig. 8)	Normal	+14·0	− 3·5	4·0	Diminution of the quotient A/K by propionic acid in optimum concentration. A is absolutely diminished. K is absolutely augmented.
		Propionic acid, N/10			
	5—6 mins.	+ 6·0	− 4·5	1·3	
	30—31 "	+ 4·0	− 3·0	1·3	
2413	Normal	+16·0	− 5·0	3·2	Diminished A/K by relatively greater increase of K than of A.
		Propionic acid, N/20			
	3—4 mins.	+23·0	− 9·0	2·5	
2422 (fig. 10)	Normal	+10·0	− 1·5	7·0	Diminution of the quotient A/K by CO_2.—During passage of CO_2, A is absolutely diminished, K is absolutely augmented. Subsequently both A and K are absolutely augmented, but the augmentation of K is relatively greater than that of A, so that the quotient A/K is below normal.
		CO_2 for 8 mins.			
	1—2 mins.	+ 5·5	− 5·5	1·0	
	7—8 "	+15·0	− 5·0	3·0	
	11—12 "	+11·0	− 1·5	7·7	
2426	Normal	+23·5	− 6·5	3·6	Diminished A/K by relatively greater increase of K than of A.
		Formic acid, N/40			
	2—3 mins.	+26·0	−10·0	2·6	

2428—9 (fig. 6)	Normal	+19·0	– 6·0	3·2	Augmentation of A/K by ammonia vapour, with absolute diminution of K. Subsequent diminution of A/K by CO_2, with absolute augmentation of K, and absolute diminution of A.
		1 per cent. NH_3 vapour for 3 mins.			
	0—3 mins.	+19·5	– 7·0	2·8	
	4—5 "	+19·5	– 6·5	3·0	
	10—11 "	5 per cent. NH_3 vapour for 3 mins.			
	13—16 "	+18·5	– 6·0	3·1	
	20—21 "	+19·0	– 3·0	6·3	
	21—25 "	+16·5	– trace	—	
	41—42 "	CO_2 for 3 mins.			
	49—52 "	+10·0	– 7·0	1·4	
	53—54 "	+13·5	– 7·0	1·9	
	55—56 "	+17·0	–10·0	1·7	
	57—58 "	+17·5	–12·5	1·4	
	59—60 "	+18·5	–10·5	1·8	
	61—62 "	+18·0	– 8·0	2·25	
	63—64 "				
	69—70 "	+17·0	– 4·5	3·8	
2432 (fig. 7)	1—2 mins.	+23·0	– 8·0	2·9	Augmentation of the A/K quotient by NH_3.
	3—4 "	+23·5	– 7·0	3·4	
	5—6 "	+24·0	– 6·0	4·0	
		5 per cent. NH_3 vapour for 4 mins.			
	7—8 "	+24·5	– 5·0	4·9	
	9—10 "	+24·0	– 3·5	6·8	
	19—20 "	+23·5	– 2·5	9·4	

Table II.—Influence of Five Minutes' Tetanisation on the A and K Currents provoked by one Leclanché Cell.

(Inter- and Intra-polar Distances each of 1 cm.)

Plate No.	Time.	A.	K.	A/K.	Remarks.
2294	Before After	.. ..	− 8·5 − 9·5	..	Coil at 50. Slightly augmented K.
2295 (fig. 14)	Before After	+31·5 +34·5	..	..	Coil at 50. Augmented A.
2296 (fig. 15)	Before After	+19·0 +12·0	..	..	Coil at 50. Diminished A.
2297	Before After	.. ..	− 7·5 − 7·5	..	Coil at 50. No marked effect.
2298	Before After	+10·0 + 8·0	..	..	Coil at 50. Slightly diminished A.
2299	Before After	+10·0 +11·5	..	..	Coil at 50. Slightly increased A.
2387	Before After	+14·5 +14·5	− 5·5 − 4·5	2·65 3·2	Coil at 50 units. Diminished K. Augmented A/K.
2388	Before After	+25·5 +31·5	− 9·0 − 9·5	2·8 3·3	Augmented A and augmented A/K. Coil at at 20 units.
2389	Before After	+21·0 +25·0	− 6·0 − 7·0	3·5 3·5	Augmented A and augmented K. Coil at 20.

2390	Before After	+13·0 +16·5	− 3·5 − 4·5	3·7 3·7	Augmented A and K. Coil at 20.
2391	Before After	+29·0 +32·0	− 7·5 −10·5	3·9 3·0	Augmented A and K. Diminished A/K. Coil at 20.
2393	Before After	+12·0 +14·5	− 4·0 − 4·0	3·0 3·6	Augmented A and augmented A/K. Coil at 20.
2394	Before After	+14·5 +15·5	− 6·5 − 6·5	2·2 2·4	Ill-marked effect. Coil at 20.
2395	Before After	+15·0 +15·5	− 9·0 −11·0	1·7 1·4	Augmented K. Diminished A/K. Coil at 20.
2423	Before After	+19·0 +22·0	− 4·5 − 5·0	4·2 4·4	Augmented A and K. Coil at 20.
2424 (fig. 11)	Before After 15 mins. later	+15·5 +11·75 +14·5	− 1·0 − 6·5 − 3·0	15·5 1·8 4·8	Diminished A. Augmented K. Diminished A/K. Typical effect. Coil at 20.
2425	Before After	+20·0 +19·5	− 4·0 −11·0	5·0 1·6	Augmented K. Diminished A/K. Coil at 20.
2427	Before After	+11·0 +13·0	− 2·5 − 4·5	4·4 2·9	Augmented A and K. Diminished A/K. Coil at 20.

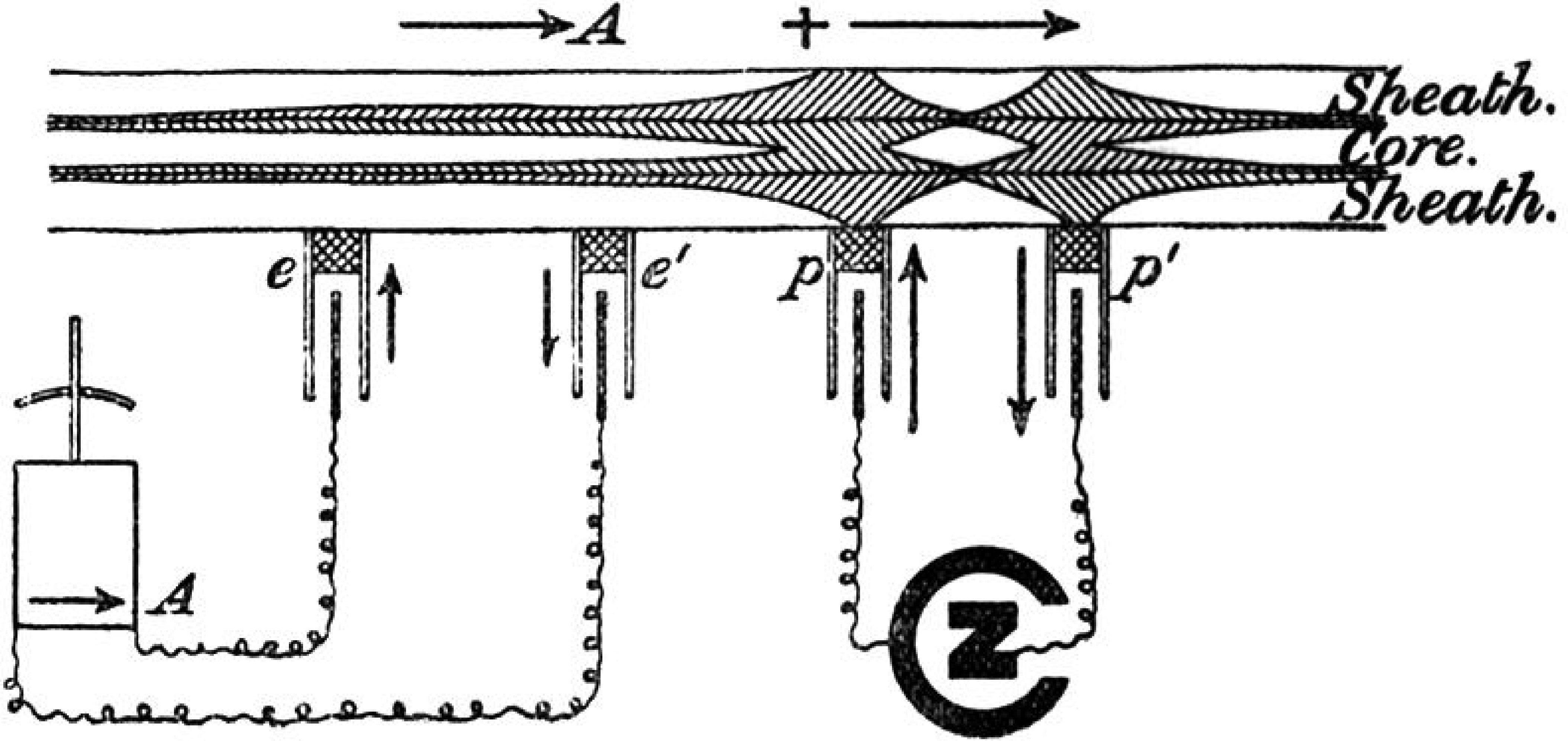

FIG. 1.

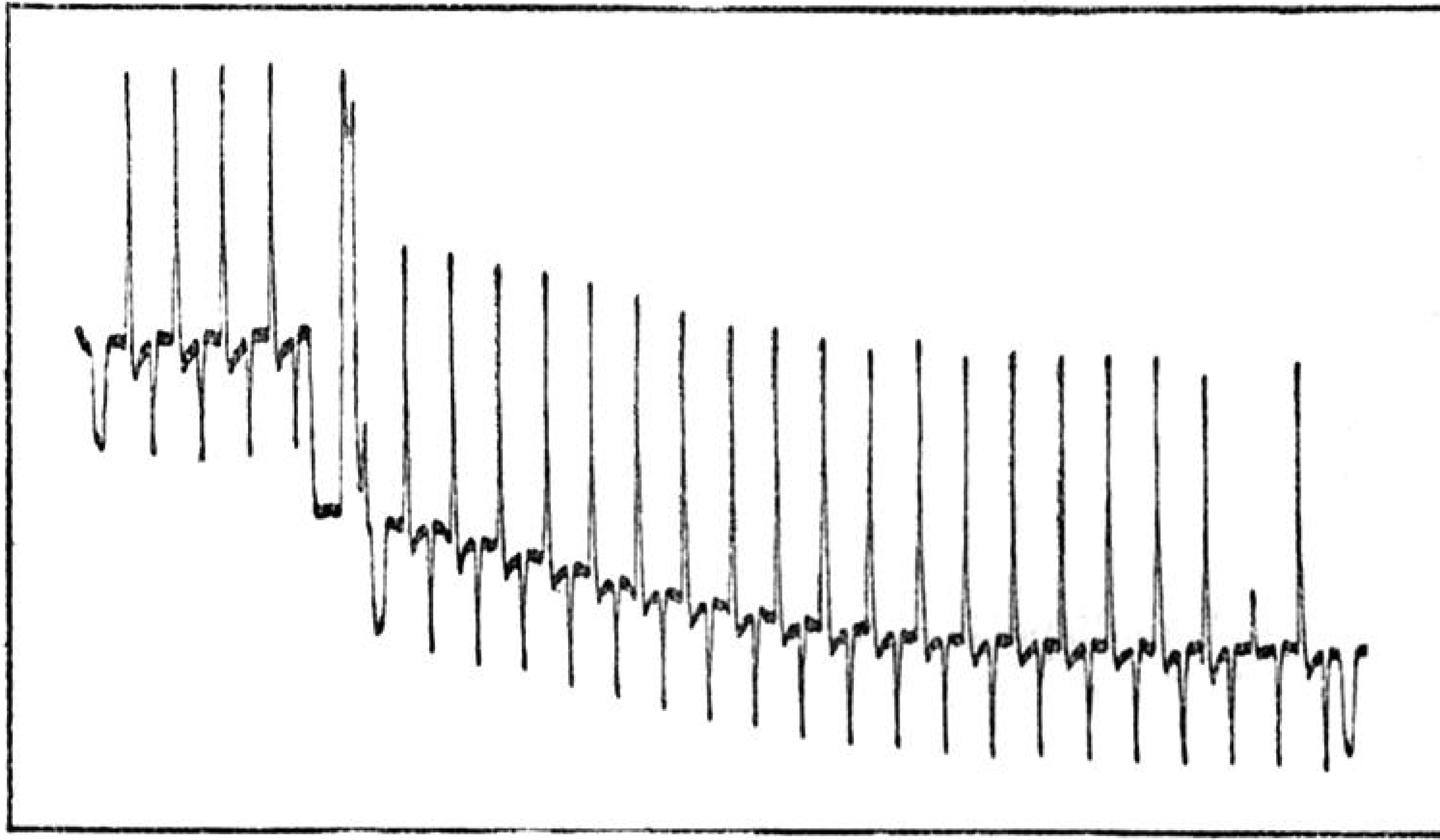

FIG. 2.—Potassium hydrate, N/50 (2358).

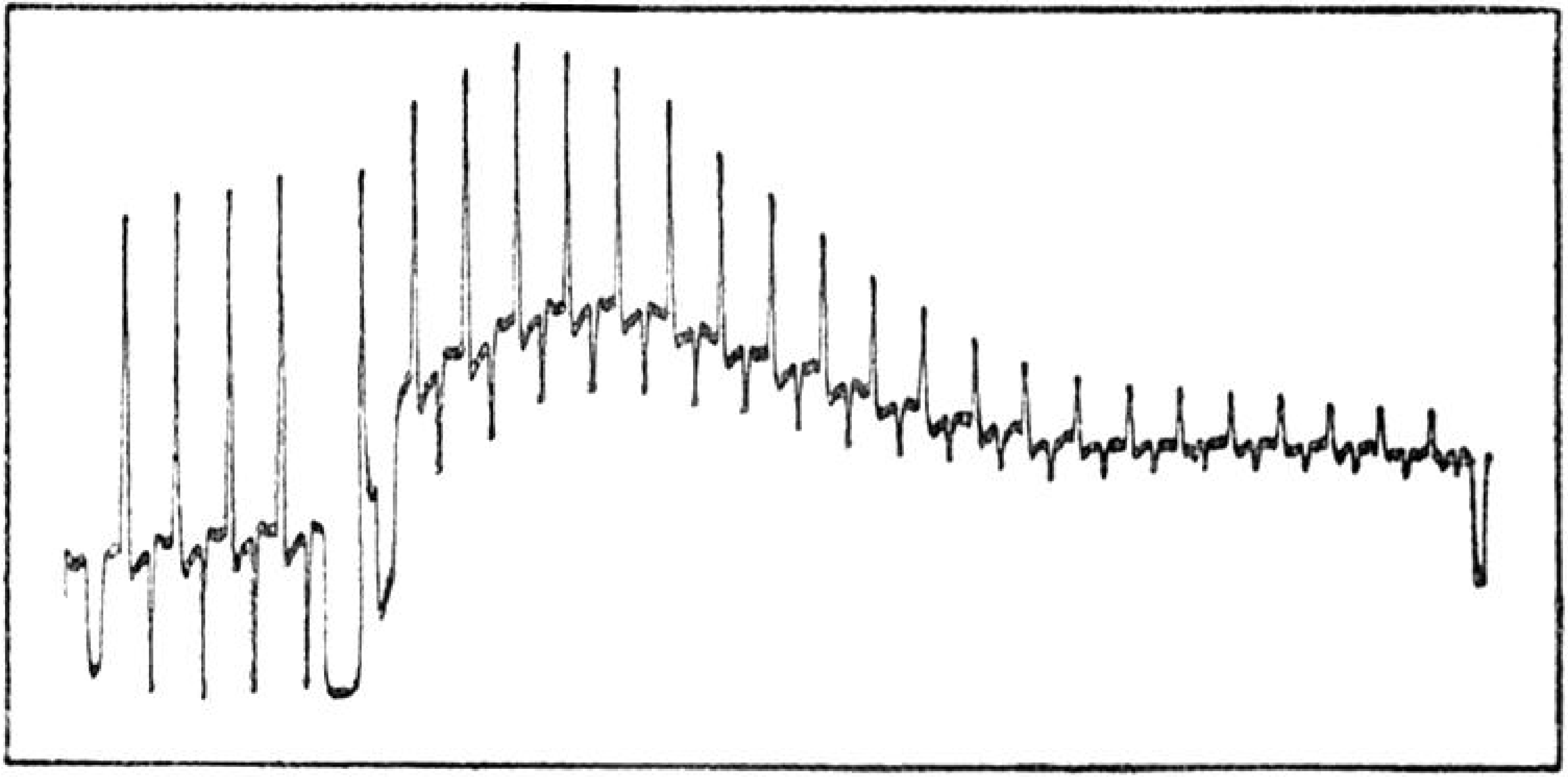

FIG. 3.—Effect of sulphuric acid, N/5 upon A and K (2359).

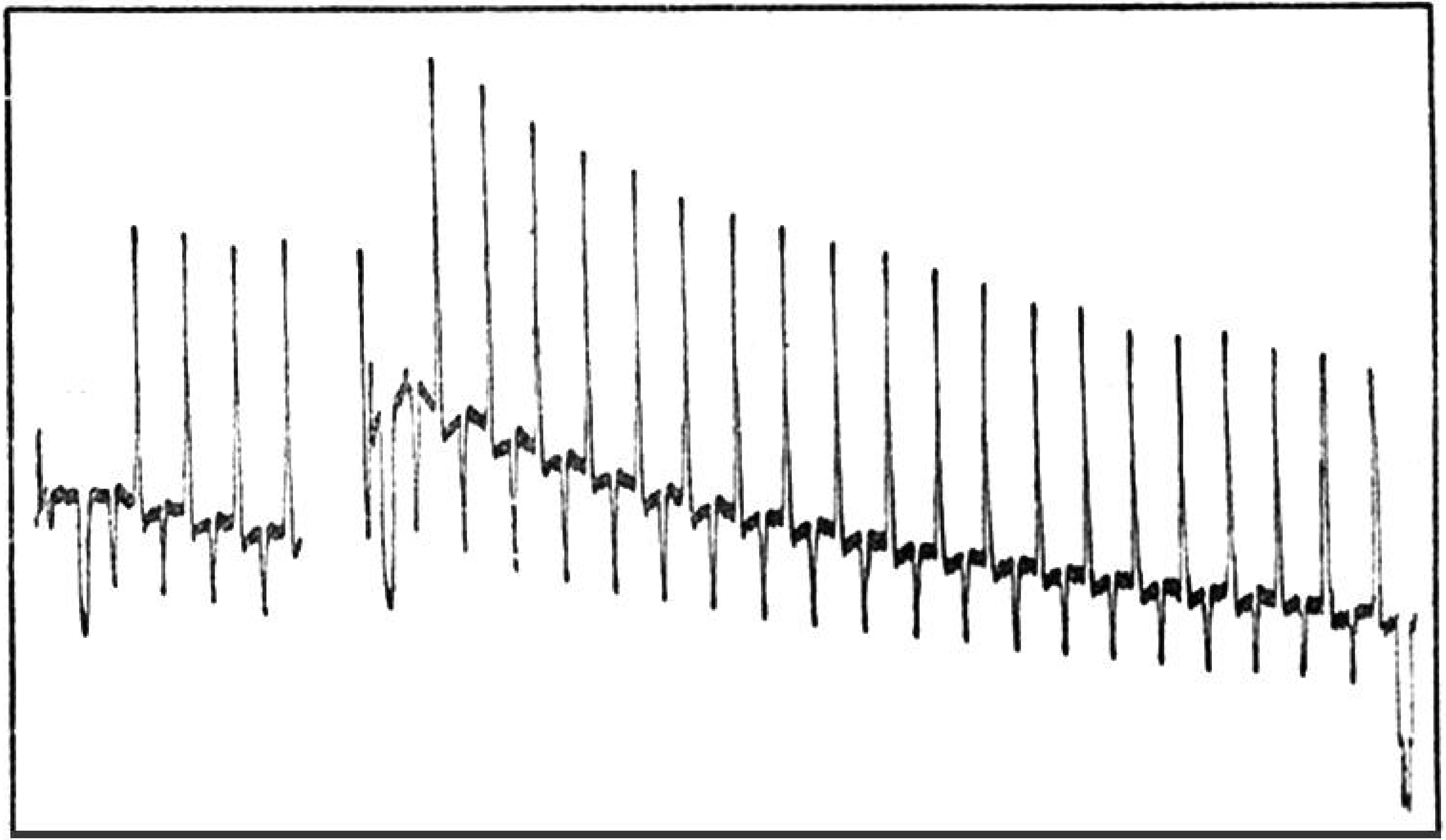

FIG. 4.—Oxalic acid N/20 (2410).

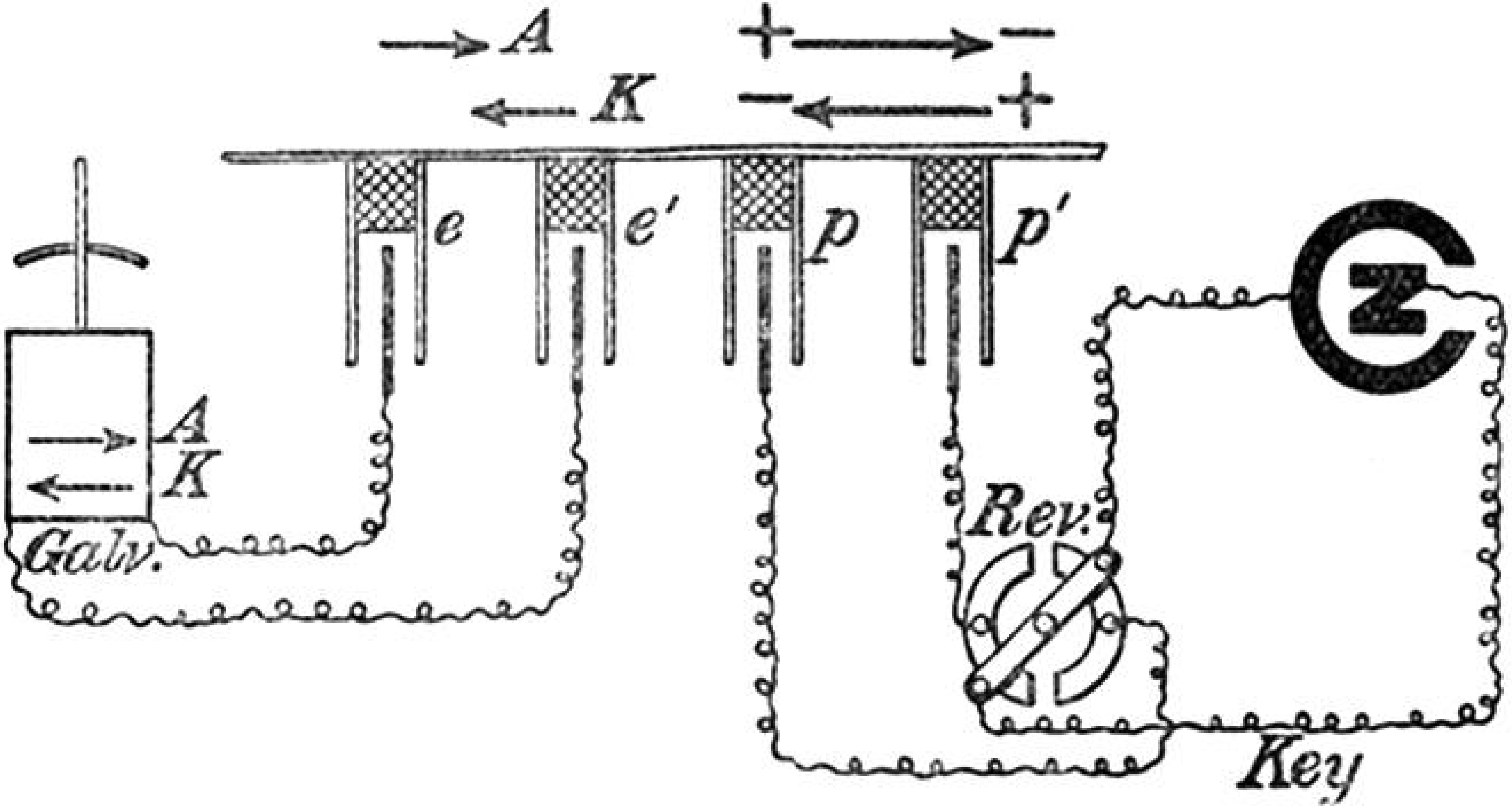

FIG. 5.—Diagram of apparatus. The excised nerve rests upon two pairs of unpolarisable electrodes, *pp′* leading in the polarising current, *ee′* leading out the extrapolar or electrotonic current.

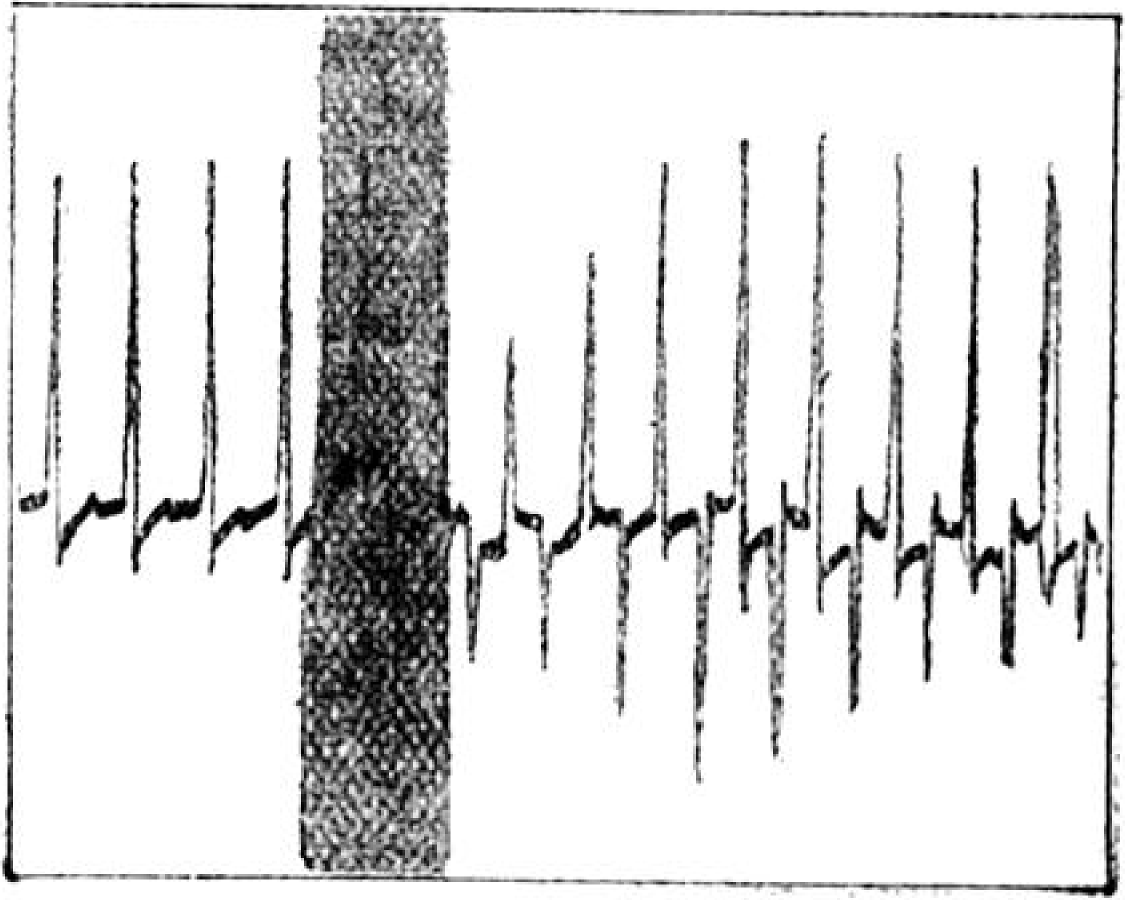

FIG. 6.—Action of CO_2 on A and K (2429).

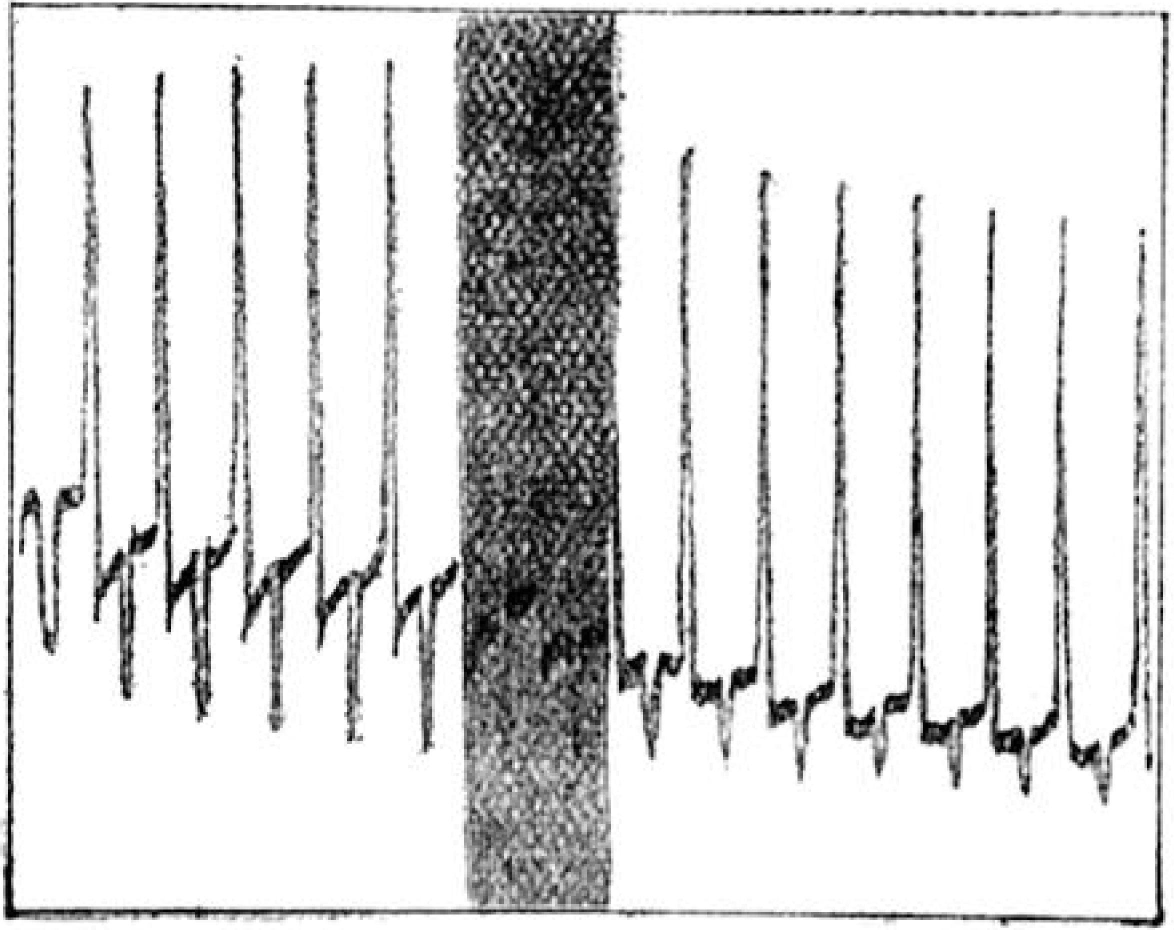

FIG. 7.—Action of ammonia vapour on A and K (2432).

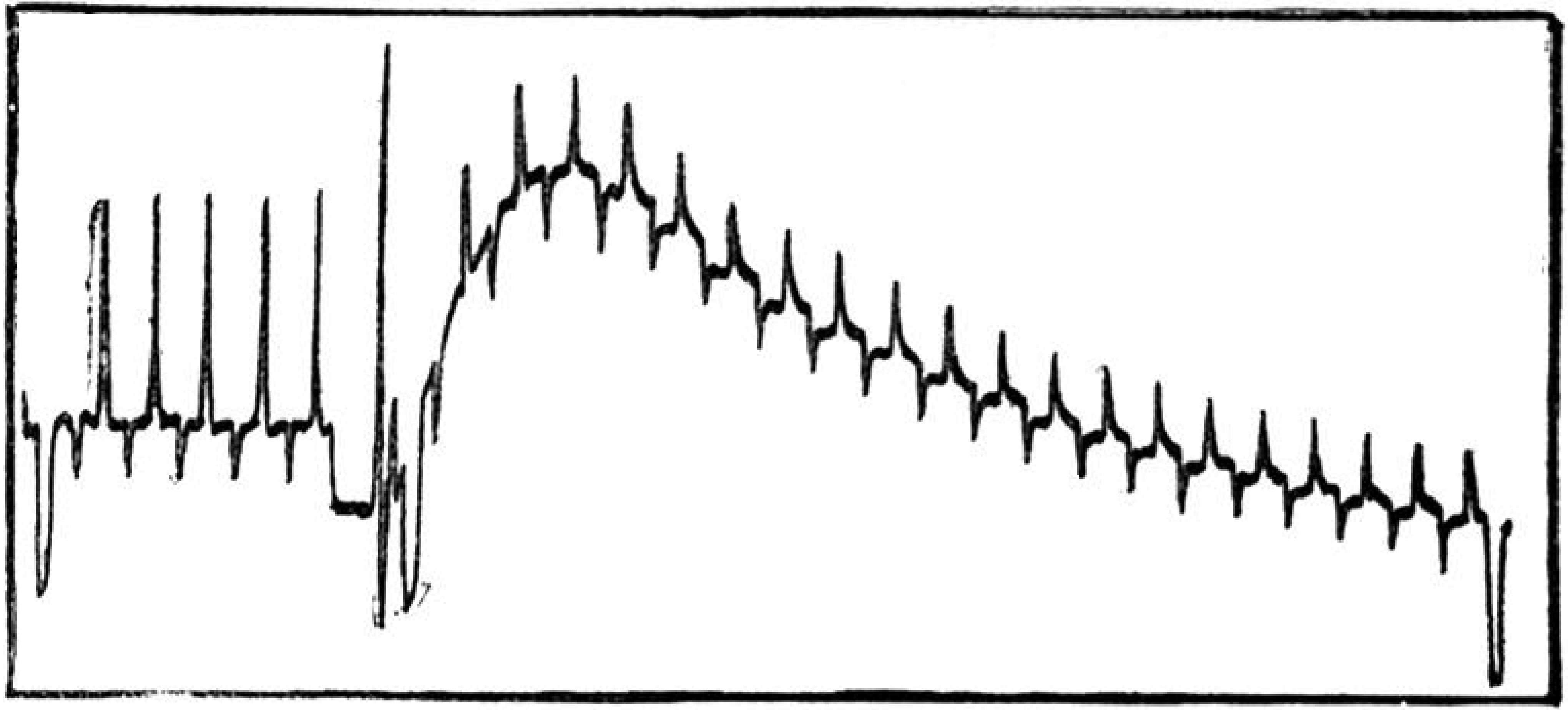

FIG. 8.—Effect of propionic acid, N/10, upon A and K (2412).

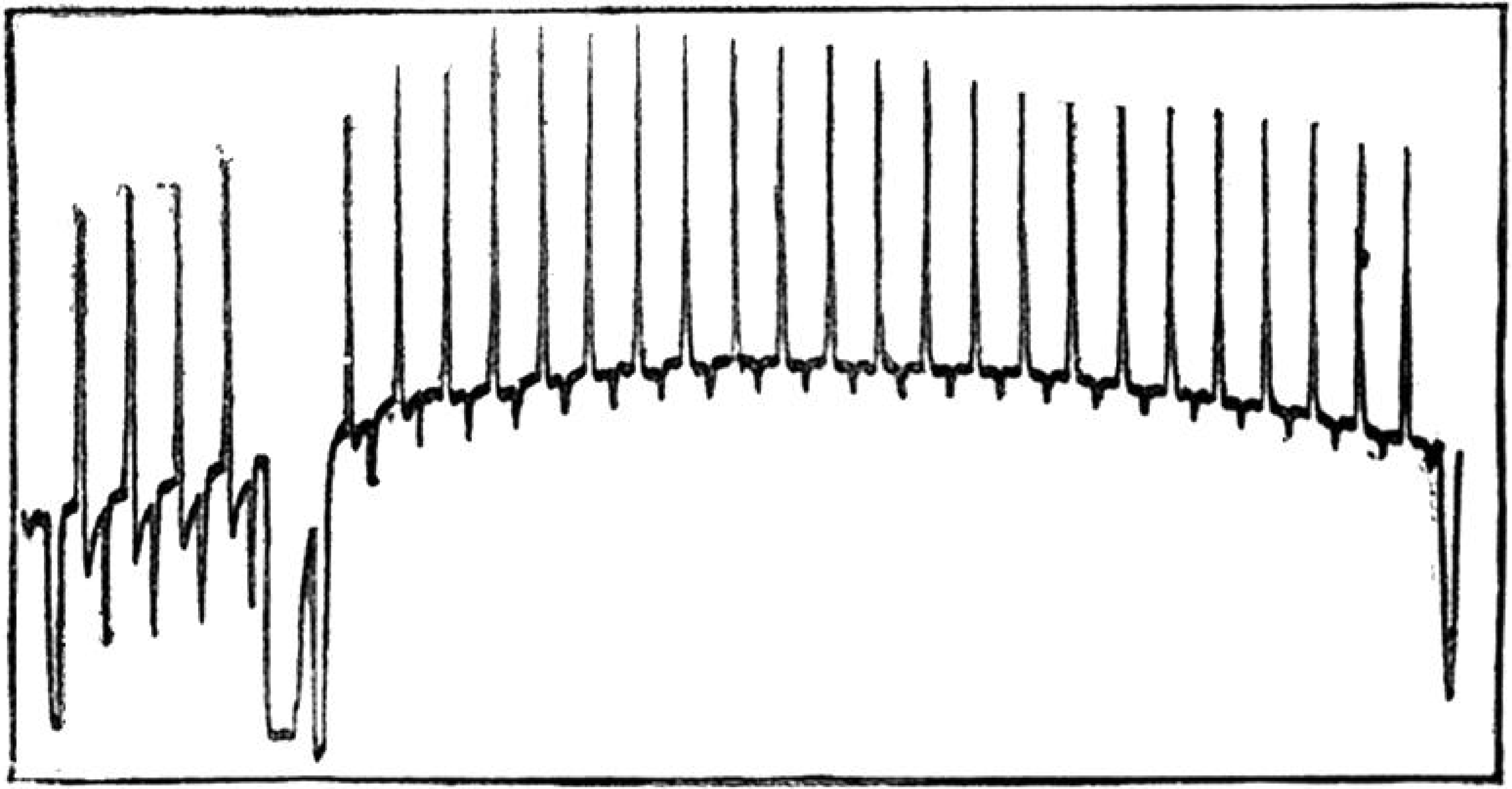

FIG. 9.—Effect of a weak alkaline bath (KOH N/20 or 0·285 per 100) upon A and K (2360).

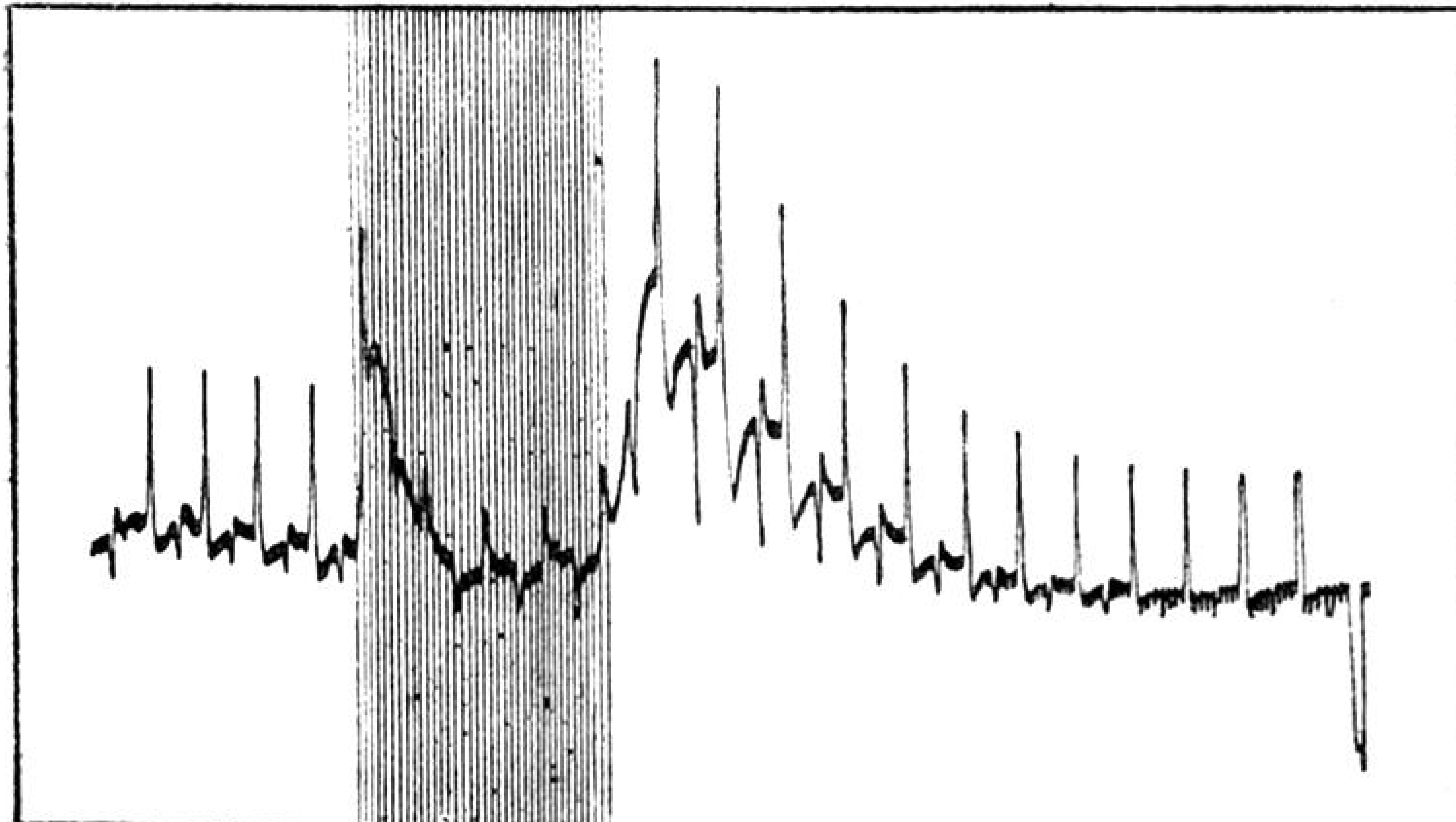

FIG. 10.—Action of CO_2 upon A and K (2422).

* 'Phil. Trans.,' B, 1897, p. 1.

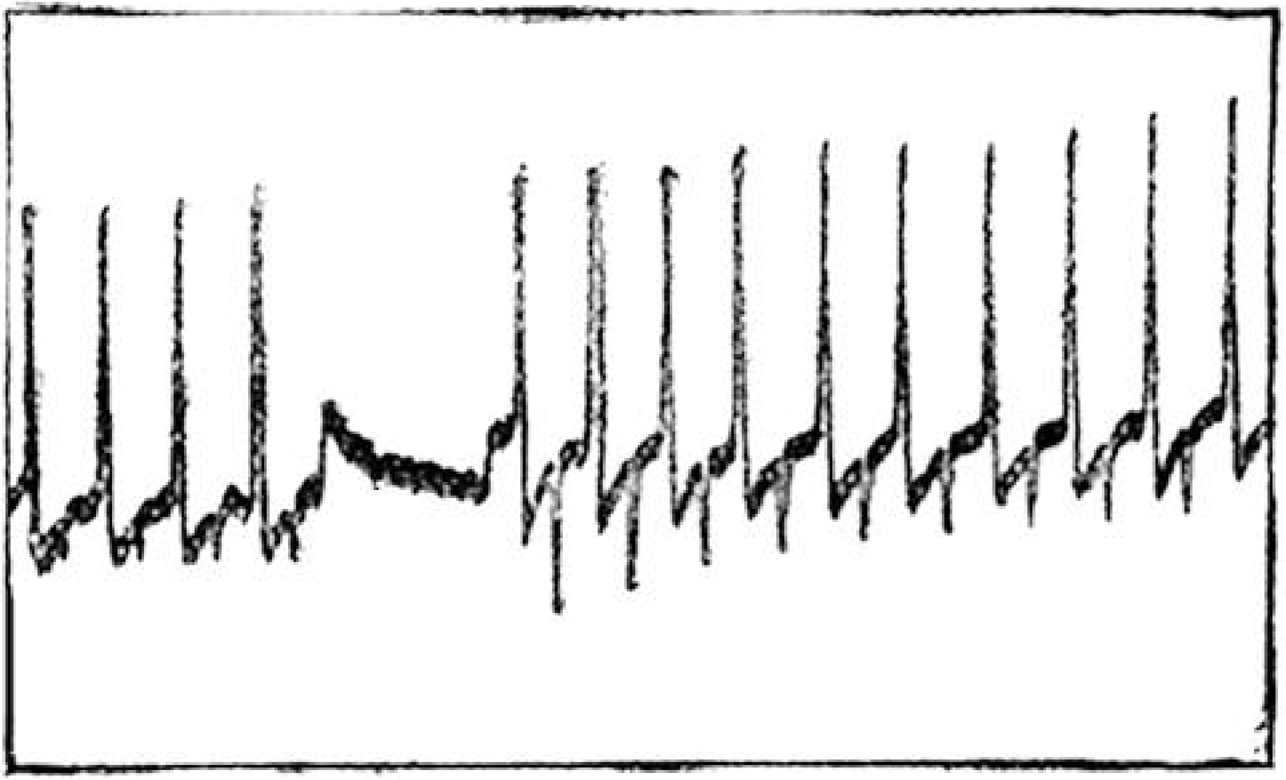

FIG. 11.—Effect of tetanisation on A and K (2424).

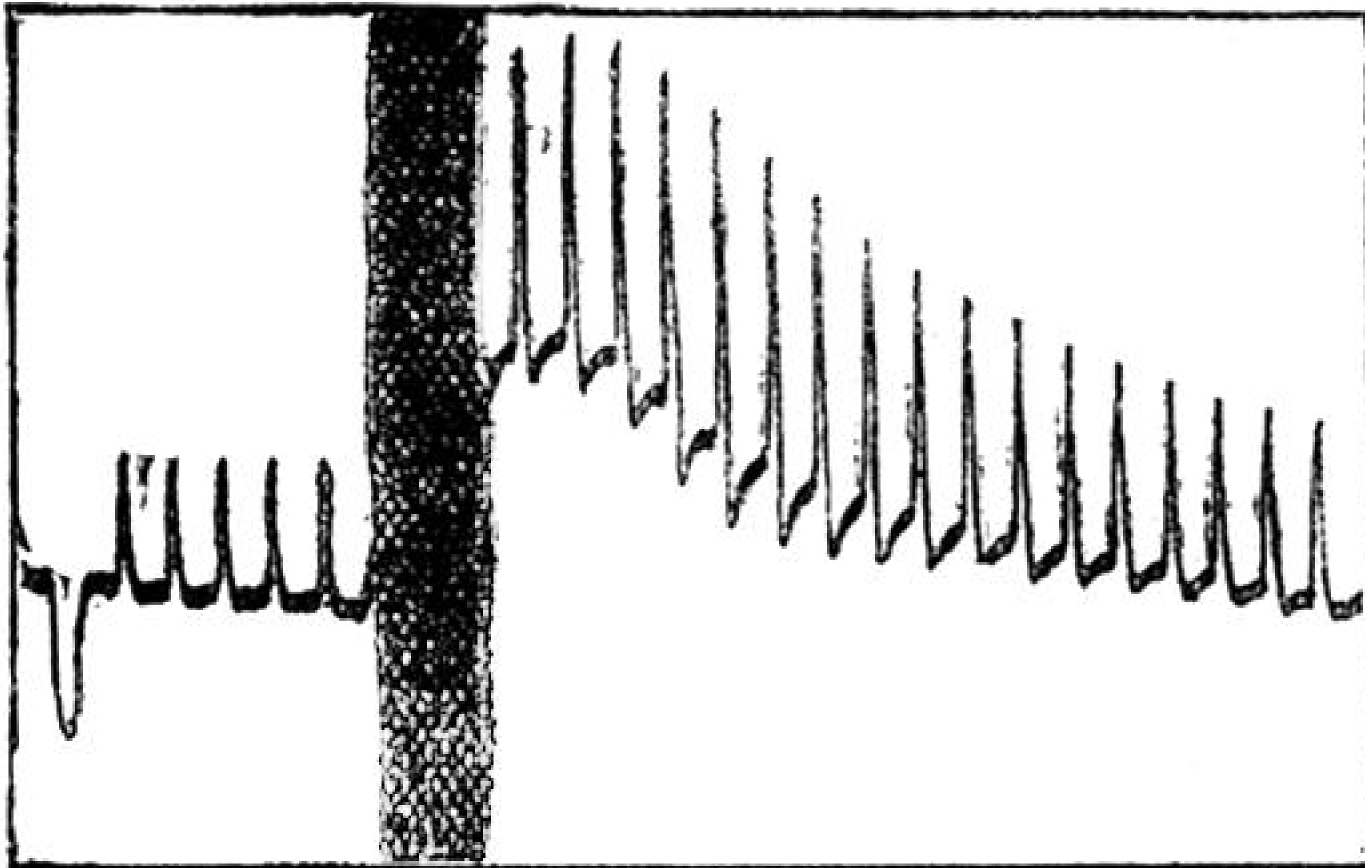

FIG. 12.—Effect of CO_2 on A (primary augmentation) (2199).

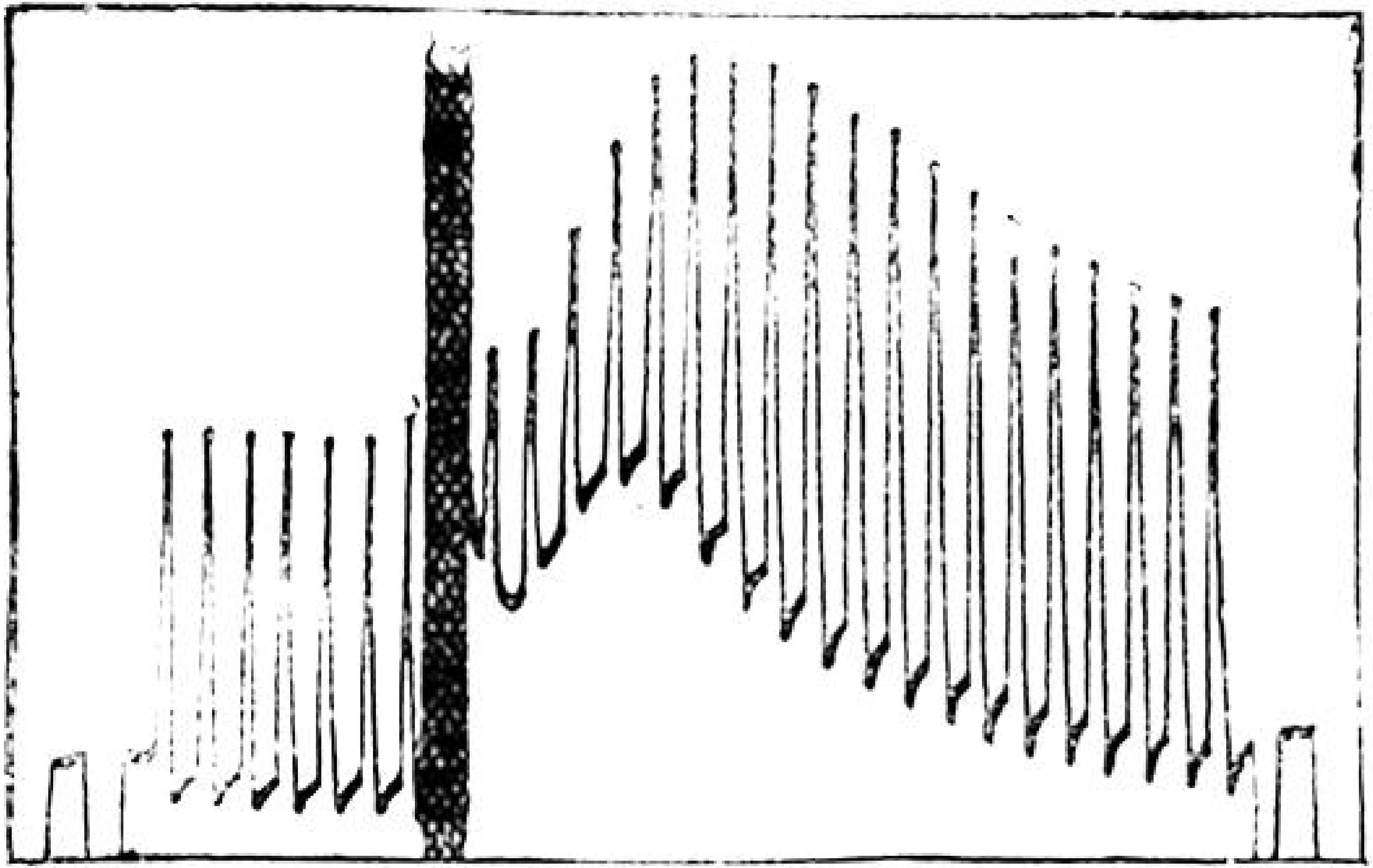

FIG. 13.—Effect of CO_2 on A (primary diminution, secondary augmentation) (2200).

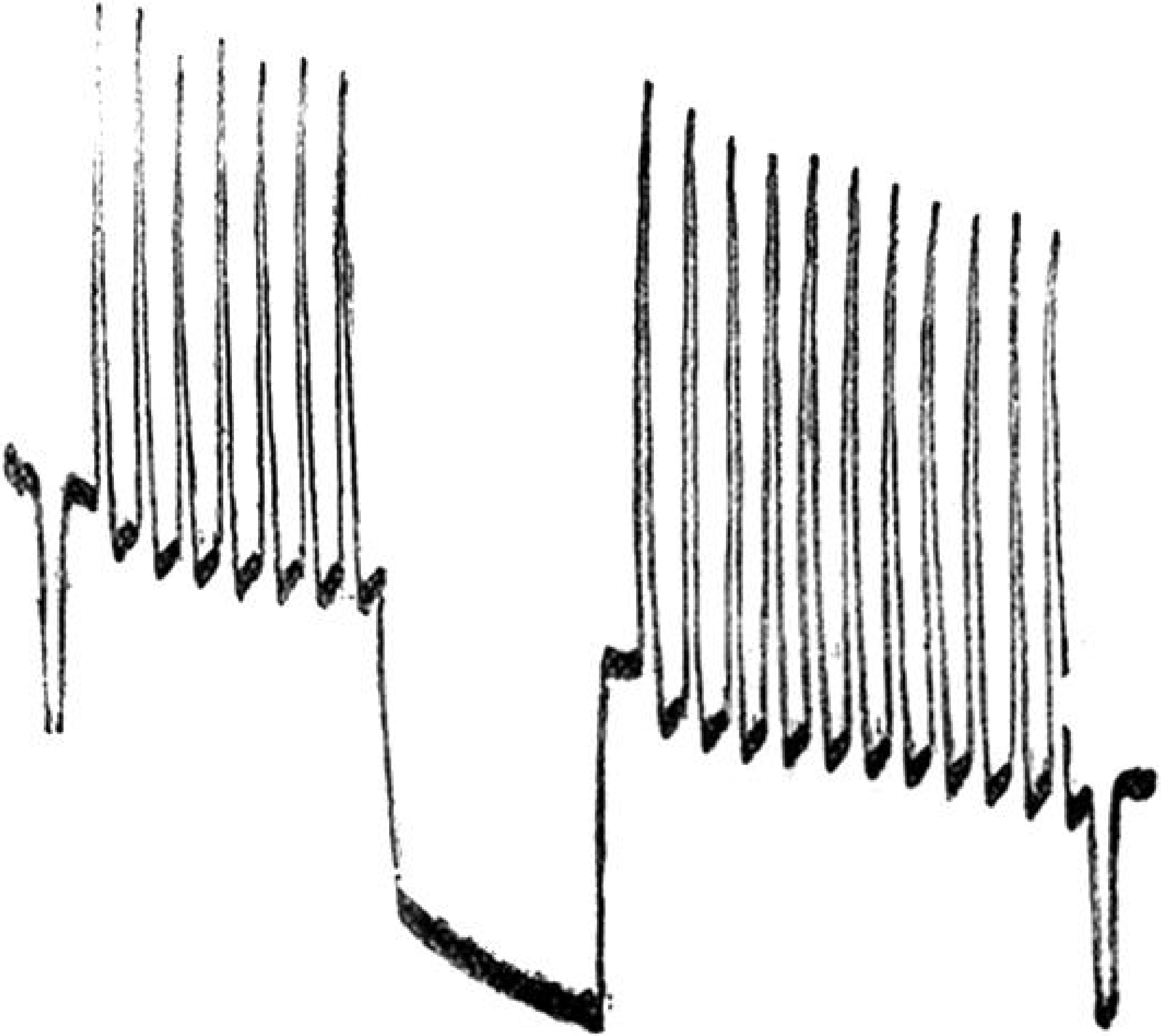

FIG. 14.—Effect of tetanisation on A (augmentation) (2295).

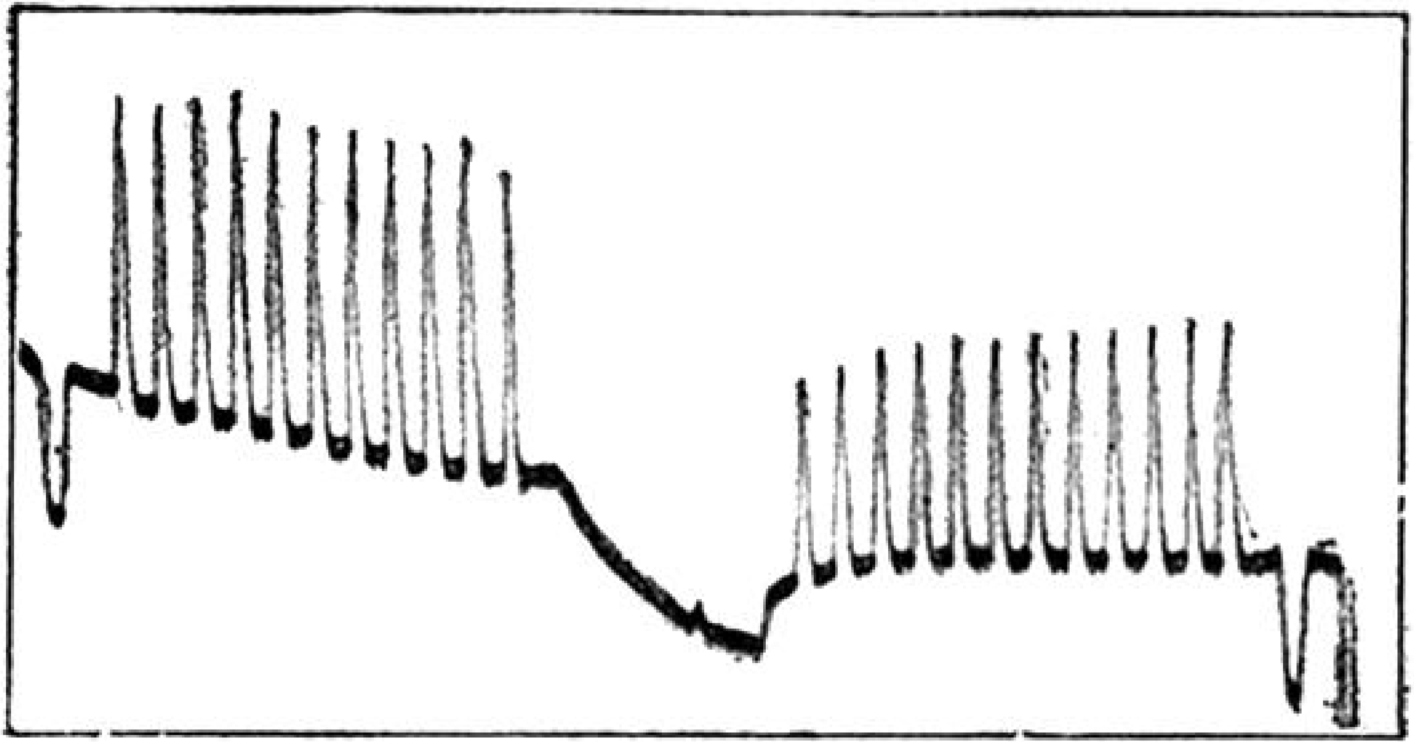

FIG. 15.—Effect of tetanisation on A (diminution) (2296).